SCIENCE

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MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

SCIENTIFIC TRUTH AND THE SCIENTIFIC SPIRIT[1]

IN appearing before you this evening in my present rôle I can not but recall an incident of fifty-five years ago, which often recurs to my mind when I think of the events of to-day.

The trustees of the Smithsonian Institution in 1861 were preparing their programme for the year, and in this programme were courses of lectures to be given to the public on a series of selected topics. Their intention was announced and they were importuned to devote those lectures to what was at that time in everybody's mind. It was the first year of your great war of the Secession. I say your war, but I might, with some justification, have called it our war, for there fought in the ranks of the armies of the North 68,000 British citizens, of whom 45,000 were Canadians, and of the latter 15,000 lost their lives. There were even then stop-the-war people, prototypes of the Fords, the Akeds, the Jane Addamses and the Lloyd Joneses of to-day, futile, mole-visioned and cloister-minded, who imagined that the great conflict could be prevented by talking and they wished to avail themselves of the opportunity the lectures might present of showing how it could be done.

The trustees apparently wished to be neutral, perhaps they were uncertain what the upshot of the conflict was going to be, and this may have helped them to decide, as they did, that all war topics should be

[1] Address delivered at the annual dinner of the Columbia Biochemical Association, February 10, 1916.

excluded from their program. To secure that they invited Professor, afterwards Sir Daniel Wilson, of the University of Toronto, to give a course of lectures on "Prehistoric Man." Professor Wilson was eminent for his attainments and achievements in many fields, but he was chiefly known at the time as a pathmaker in what were then the trackless wilds of the earliest history of our race, and, therefore, the selection of him as a lecturer on the subject could not have been more aptly made. It was a fortunate selection from another point of view. His subject could not be remotely associated with the war then begun, but, had it been otherwise, his habit of mind prevented him from alluding to it in his lectures, and not even once in his conversation during his stay in Washington did he indicate the slightest interest in the great struggle. There were occasions when he could have referred to it. Frequently during the delivery of his lectures the boom of cannon heard in the lecture room—coming from across the Potomac—punctuated his sentences. According to the late Dr. Otis T. Mason, who was my informant on this subject, he left as a memory of his visit a reputation for mental detachment that was Olympic in its character.

This evening I appear before you in a rôle which is in some respects parallel to that filled by Sir Daniel Wilson on that occasion, but there are in it contrasts also. Your country, your nation is now at peace and it is my country that is at war, engaged in a struggle unparalleled in history. Canada has already played a part and she is preparing to play a larger one. She is to increase her army of 200,000 men to half a million, that is, to train and arm five men out of every twelve of the male population between the ages of eighteen and forty-five. That will indicate the magnitude of the task we have undertaken. There can be no mistaking the seriousness with which we regard what is before us. Our young men are preparing to do their duty and to pay the toll that may be exacted. Daily through my laboratory windows comes the sound of the drilling of more than seventeen hundred men, which goes on from morn to night on our university lawn. We have already sent seven hundred of our students and young graduates overseas on active service and we have now a continually lengthening roll of honor with its sad, yet noble, memories of those whom age shall not weary nor the years condemn. The end may be far off and the future is dark and heavy with fate, but we are going forward with the determination that, though life will never again be as it was in the joyous, carefree past, a new world shall come into being as a compensation for the sacrifices that we are making and are yet to make. We are certain above all things of one result, and it is that this war is forging on the anvil of destiny, in the fierce furnace heat of the conflict, the scattered, loosely-knit portions of our Anglo-Celtic empire into an organization, an instrument that shall be a guarantee of happiness and liberty to countless millions yet unborn.

It is the thought of all these things crowding in on my mind that prevents me from adopting the absolutely detached, Olympic mind that Sir Daniel Wilson displayed when your nation was being welded into one in the furnace heat of the great Civil War. I am not, however, going to allow these thoughts to crowd out those which it is my duty to express to you on this occasion. I must look forward, as you must also, to a time when the welter of baleful hatred and paleolithic fury of the

hour will be past, though not forgotten, to a time when men of science of all nationalities may, under better auspices, and in spite of the chauvinism that will be the result of this war, cultivate once more a camaraderie on the intellectual high road of life. And in looking forward we must strive to strengthen those forces which, out of all the wreckage of to-day, remain to assist us in restoring what we, two years ago, were wont to believe could never be swept away.

What are those forces? They are scientific truth and the scientific spirit, both of them intangible entities or principles, but for all that destined to play a part in the restoration of the world to sanity.

It is upon these that I am to dwell this evening, and I have chosen them as the subject of my address in the hope that, in holding your attention for the moment, I may direct your thoughts to questions which are of enduring interest to all workers in science.

To workers in biochemistry these topics are of fundamental importance because our attitude toward them, our comprehension of their significance, determine our usefulness as scientific investigators. As students of the phenomena of living matter we are constantly in touch with problems which, to many, seem inscrutable, inexplicable on the basis of our present knowledge. There is in the make-up of our personalities a tendency to classify the inexplicable as transcendental and to believe that in living matter there operate forces that can never be scrutinized and examined as we examine the forces of the ordinary physical world. That tendency of mind, from which I say few are wholly free, is, when unchecked, a negation of the scientific spirit, and to a mind more or less influenced by it there can be no scientific truth, for the latter is the product of the scientific spirit.

There may be some who will ask "What is truth?" They ask the question not in the spirit and intent of the procurator of Judea, but because they are perplexed by the irreconcilable interpretations of the term "truth" as advanced in the discussions amongst the different schools of philosophical thought. The perplexity is to a certain extent natural, but it ought not to prevent us from finding an answer to the question which will meet the tests, not only of daily life, but also of the world of science, as a brief consideration of the doctrines of two diametrically opposed schools of thought may show.

Amongst the adherents of one of these schools, which I may, for the sake of brevity, call the absolute school, truth is a concept reached by processes of more or less rigid speculation and reasoning, in which, however, introspection plays a large part, explaining the world, reality and mind in terms which are wholly of dialectical coinage. The central doctrine of this system of thought is that reality and appearance are but manifestations of the activity of an entity freed or absolved from all limitations of time and capable of all that we can conceive and more, an entity that is, in consequence, denominated the Absolute. The Absolute is, in the language, some would say, in the jargon, of the school, but truth itself because it is claimed to be the product of the final analysis of the phenomena of mind and reality.

This concept of truth commends itself to minds of a rare type, chiefly those of the cloister or the study, but never to those representative of the world of action. I do not wish to be understood as deriding it or the processes by which it is reached, for I recognize that the human mind must ex-

plore its own depths and exploit its own processes, whatever the result may be, yet I would point that the world is not peopled wholly by Greens, Cairds, Bosanquets, Bradleys and Royces, and that the life and thought of the exoteric many can never but remotely be influenced by this doctrine of truth.

The other school of philosophy is a proponent of a doctrine of truth quite different from the product of pure intellectualism and which can be understood and applied by the many to daily life, and because it can be of service to them it can be absolved from the charge that "it bakes no bread." This school of philosophy holds, as its cardinal tenet, that truth is a body of beliefs or generalizations that work when you apply in it in your needs. The truth in a particular case is the generalization, great or small, that you find in accordance with the facts, and the facts themselves are isolated truths, the products of your experience, that you accept as satisfying your intellectual tests. Whatever works then in daily life is truth, and, if a generalization, or belief, can not be so applied, it has no function or significance intellectually or practically, and can not be truth as it is conceived by the disciples of this school.

This school of philosophy is known as the pragmatic school and it is generally supposed to have been founded within our own time by the late C. S. Pierce and Professor William James, of Harvard, and Dr. F. C. S. Schiller, of Oxford, and Professor John Dewey, of Columbia, who still remain its leaders. The school, however, represents an attitude of mind that has influenced the race since its origin one or more millions of years ago. Ever since the middle of the Pliocene Age, or, perhaps, even since the end of the Miocene, man has had to struggle with his environment, and that very struggle postulated a system of beliefs and generalizations, which, if they served him, represented to him truth. The beliefs and generalizations did not work, if he failed in the struggle and was exterminated. They were, of necessity, at first of the crudest, the most barbaric type and limited in their scope and application to the needs of the moment, but they were changed as they slowly underwent the test of experience, and the beliefs and generalizations of one age were discarded wholly or became the superstitions of succeeding ages. Even to-day the vast majority of mankind regard their beliefs and generalizations as true because they work or give a satisfactory explanation of the scheme of things as it appears now.

That the pragmatic point determined what truth was in the mind of prehistoric man may be gathered from the study of the beliefs and practises of those tribes which are still in the prehistoric stage of culture. Sir John G. Frazer, the author of "The Golden Bough," and one of the profoundest students of the history of human culture, in his work "Psyche's Task" claims that the evolution of some of our most cherished convictions and principles, such as the sacredness of human life, sexual morality, the rights of property and our conception of social order, was promoted by the beliefs and generalizations of prehistoric races. These beliefs and generalizations now appear to us as superstition, and of the grossest character in some respects, but this very superstition in promoting those convictions and principles on which the whole fabric of society rests has rendered a great service to humanity. Sir John Frazer admits that superstition has been productive of evil in the history of the race, but this should not blind us to the

benefit it has conferred, and he gives special point to all this by a dictum which for its brevity and concentrated wisdom is well worth remembering:

> Once the harbor lights are passed and the ship is in port, it matters little whether the pilot steered by a Jack o' lantern or the stars.

The history of the human mind is then that of long ages of discipline in pragmatism. It is the pragmatic mind that has brought man along the road of progress through the million or more years of the prehistoric period to the stage of civilization of to-day. It is the pragmatic mind that will lead him, indeed force him, along the road of progress in the many, many millions of years during which the race will possess the earth. In all that time to come he will refine more and more the processes by which he arrives at what he will regard as truth and he will subject it to ever rigider tests as the millenia pass. As a result, there will be many a discarded belief and generalization once looked upon as truth, just as there has been in the past a long series of beliefs and generalizations which for a time worked and then became superstitions. Truth then will have its paleontology just as life has, with its myriads of forms which have passed away.

To those who are inclined to accept the intellectualist's teachings, this view of truth as earth-born rather than heaven-born, appears repellant and degrading. It does not seem possible for them to idealize it as they can idealize what Carlyle calls "The eternal verities." They, with Chaucer, may hold that "truth is the highest thing a man may keep," and they are prone, accordingly, to sublimate it, as the intellectualist does, until it has no earthly affinities. They should remember that truth of the absolute school has had a repellant history. Men have in the past assumed that they were in the possession of absolute truth and they attempted to compel all others to accept it also. Not to receive the absolute truth, they held, was to murder the soul, and to prevent such murder the extremest cruelty was considered justifiable. Hence arose persecution, religious wars, death at the stake and on the scaffold, massacres of thousands and relapses into barbarism. Absolute truth has then its paleontology to remind it that it, like the truth of pragmatism, is subject to growth, to evolution, and that it may ripen only with the ages.

From all that I have said it follows that the long discussions on the nature of truth as the pure intellectualist understands it have been but vain dallyings with illusory ideas. There is no absolute truth knowable to the human mind. All that passes for such can, at best, be but a remote approximation to what may, in the final cast of thought in the far-distant future, be a dim limning of the ultimate, the absolute, the fundamental significance of the relations of reality and mind.

Now what is the bearing of all this on scientific truth?

Its significance lies in the fact that the representatives of science must always face the question of the validity of its position as an exponent of organized knowledge. There is in the popular mind a notion that the processes by which the facts and generalizations of science are established are different from those which are employed outside of the laboratory or observatory to establish the working hypotheses of daily life, or which were employed, more or less unconsciously, in the development of the most firmly founded principles on which our present social order rests. This has caused science to be regarded as a thing apart, as the lore of an oracle whose pro-

nouncements it is profanity to reject. One hears in popular speech such expressions as "science says . . ." or, "according to science," or "science teaches" and this indicates that in the mind of the average man there is a more or less developed cult of science as an infallible entity, personality, or divinity, which, like Minerva, has no earthly or human origin. It is perhaps not the popular mind that is wholly to blame for this. When one reviews the discussions and polemics of the last fifty years, which have arisen from the conflict between conservative and advanced thought, and, especially, advanced thought based on direct observation and experiment, there has not been wanting a species of dogmatism in not a few of the representatives of science, that suggests the claim of a degree of infallibility which the popular mind, superficial as it is, and because of the achievements of science, has been and is inclined to accept. It is true, the clearest-minded amongst the representatives of science never by speech or silence encouraged such a claim. Tyndall, Huxley, Kelvin, Helmholtz, Virchow and Pasteur have, in set terms, again and again insisted that science is not infallible. Huxley, throughout his long crusade for the recognition of science as a force making for progress, was specially insistent on the possibility of error in science. He it was who defined science as nothing but trained and organized common sense, a definition that ought to acquit it of the charge of claiming infallibility.

In spite of these disclaimers, the taint of a reputation for infallibility remains, and it not infrequently draws from the superficial, as well as from some who ought to know better, the criticism that the judgments of science are unstable and ought not to be regarded as having any validity when they are opposed to the established beliefs and the dogma of the day. Sometimes the exponents of the older learning denounce science as falsely so-called, or term it pseudo-science. At one time that was the stock charge against science, and it had its effect on the unthinking. It still is launched against science chiefly in the polemical publications of the orthodox theological school.

It is, however, when the criticism comes from the rank and file of the army of science that it does the most mischief, and especially so when it is urged in defence, not of religious beliefs or dogmas of a philosophical school, but of dogmas like vitalism, the acceptance of which postulates a negation of the established methods of science.

It is not difficult, though not fair, to charge science with pretensions to infallibility, then to recall its mistakes, its discarded theories and generalizations and thereby to impugn its claims to speak with authority on matters with which it busies itself. That appeals occasionally to the man in the street and it gains a little, perhaps desired, notoriety for the critic, but does it help us in the final cast of things to question the hard-won achievements of the human mind and say that they are naught? By what other methods than those followed in scientific research can organized knowledge be gained? Is it by intuition, revelation or the dialectics and pipe-dreams of the intellectualists? It is, therefore, beside the mark for Von Uexküll to ask "Was ist eine wissenschaftliche Wahrheit?" and to answer "Ein Irrtum von heute." In a different spirit and with a world of difference in ultimate meaning is the observation of Huxley that "history warns us that it is the customary fate of new truths to begin as heresies and to end as superstitions."

Science, then, is not infallible and never can be. Equally lacking is the quality of infallibility in scientific truth. The essence of a truth in science lies in its power to explain phenomena in a satisfactory way. If it does not do this, then it is not a truth. In a certain stage of the development of scientific knowledge a theory is found to explain or relate all the known facts in a particular range of phenomena. This is the source of the satisfaction it gives to the scientific mind and at that stage it is accepted as a truth. But subsequently discovered facts in the same province may refuse to be so explained or related, and the previously accepted truth will, consequently, be discarded for one that will give this service.

An illustration is to be found in the history of the theories of light. Newton held that light emanated from its source in the form of excessively minute particles or corpuscles, which were supposed to travel with enormous velocity. This "corpuscular" theory in his day and for a hundred years after seemed to explain all the then known phenomena of light. It was not only satisfactory in this respect, but it stimulated further inquiry in the subject. This eventually led to the promulgation of the "undulatory" theory, according to which light is but a wave motion in the cosmic ether. For the last hundred years this has been accepted as a truth, but in its turn it is failing to explain all new facts as they are ascertained, and its acceptance in its original form as a truth may eventually terminate.

If this is scientific truth, what is there to prevent it from running riot, confusing and misleading rather than guiding?

The only preventive force is the scientific spirit. It is a development of the quality or tendency of the mind which has compelled man in all the periods of his history to discard or to recast his truths because they do not work, and to accept new ones because they do work. That tendency in common life has operated crudely and slowly, it has caused countless mistakes and the temporary acceptance of countless errors, but it has brought us to our present stage of civilization. It is indeed nothing else than the pragmatic spirit. The scientific spirit is the pragmatic spirit trained in the strictest fashion to accept only what answers rigid tests and reinforced by an intense curiosity or desire to know. The very essence of this spirit is manifested in the habit of unceasing, relentless criticism. Without such incessant criticism there would be chaos in science. The scientific spirit, as thus understood, is an all-powerful factor in establishing scientific truth.

To some of you, perhaps to many of you, what I have said may appear as a restatement of a series of truisms, and I am prepared to admit that. I have, however, dwelt on these matters at length because they are of fundamental importance to men of science generally, and, amongst these, to biochemists, especially of the younger generation, who have now to meet an extraordinary situation in which these matters are involved.

A brief sketch of the history of biochemistry to the present date will demonstrate what this situation is.

It would be difficult to say when the history of biochemistry actually began, for all through the last century a number of contributions to chemistry were made which can now be regarded as contributions to biochemistry. The history of biochemistry, however, as a distinct department of knowledge, may be said to have begun with Hoppe-Seyler in 1867 in the work from his laboratory, which he subsequently published under the general title of "Medicinische-Chemische Untersuchungen." The

number of publications from all sources, which appeared annually during the seventies was small, and even in 1884 when I began to interest myself in the subject it did not, all told, exceed more than three hundred a year. It was possible for a biochemist then and for a few years thereafter to keep in touch with all advances in his subject, but eventually the number grew and in 1905 the year's output of biochemical publications of all kinds was estimated to be about three thousand five hundred papers. It did not cease to grow and the output of 1913 was more than six thousand.

The task of the scientific spirit in 1870, so far as the exercise of relentless criticism was concerned, was easy, for the dozen or more biochemists could supervise the whole field of production and pronounce judgment. That function was carefully and deliberately performed. It is on record that when Miescher, who had been for some time a student in Hoppe-Seyler's laboratory in Tübingen, offered his paper, now classical, on nuclein, for publication in the "Medicinische-Chemische Untersuchungen," Hoppe-Seyler would not publish it till he himself had worked over the whole subject and verified all the observations of Miescher. The publication of the paper was, in consequence, delayed two years.

What could be done in 1870 can not be done now, when the mass of literature being poured out in every department of biochemistry is so overwhelming. It is still possible for the head of a laboratory to censor its productions and a number of the leaders exercise that function, but what they do in this subject ameliorates the situation only to a slight extent. There is still, as any one can see, too little criticism of value in the annual output. One gets the impression, in reviewing the literature on a subject, that the contributors to it regard criticism as not within their province, and that they are anxious to get their own views on record without going through the labor of preparing a critical review of that literature. There is in consequence an ever increasing dependence on Jahresberichte, Centralblätter and Ergebnisse. Even when the function of criticism is exercised the situation is not always thereby bettered, for the criticism not infrequently is slipshod or specious, and the result is only polemics, or it is completely ignored.

It may be urged that the criticism to be effective would increase the length of each contribution, which on the average is sufficiently long already. The answer to this is that effective criticism would in the end not only shorten the length of the papers, but also lessen their numbers.

The haste to publish and the tendency to multiply unnecessarily the number of papers are vices which should be curbed. The fact that they are so prevalent is due to the absence of effective criticism.

In claiming that criticism is the essence of the scientific spirit, I must not be understood as justifying criticism of the undiscriminating or reckless type. That is utterly senseless and is a graver fault than the absence of all criticism. Criticism, to be effective, must be judicial, honest and, above all, courteous to the object of it. Criticism of that type no man can refuse or reject and it is extremely valuable to the individual who is subjected to it, as he will admit sooner or later if he is of the right sort. It is the only means of determining whether what he offers as a contribution is going to work.

To inculcate right standards of criticism there should be given in every university a course of lectures on ethics for all those who propose to devote themselves to a scientific career. There might even be, I would suggest, a brotherhood like the ancient Brotherhood of Hippocrates, the members

of which would vow to devote themselves to the cause of truth, to deal justly and courteously with one another and with all laborers for that cause and to keep the scientific record purged of what is false or mean.

Not to dwell further on this subject, I will now briefly emphasize the central points of this address:

The first is that absolute truth is not knowable, and that even to the end of time it will be so.

> The unfinished window in Aladdin's Tower
> Unfinished must remain.

The second point is that scientific truth of any age is that which works and consequently it may change and present a new aspect with each succeeding generation.

The third is that the scientific spirit is, when rigorously exercised, the only test of what works or what is scientific truth.

The last point is that science is not and never can be infallible, and we should be thankful for that, for, if it assumed infallibility, the progress of the human mind on the path of truth would cease.

Before I conclude finally I would call attention to a rendition of the ideal scientific spirit which is to be found in a passage of Tennyson's "Ulysses." The old hero is there represented as having, after ten long years before the walls of Troy and ten more years of peril and adventure on the sea, returned to Ithaca, his old home, and as now resolving to take up the life of change and discovery even though the gulfs should wash him down. The passage which I quote should be indelibly fixed in the memory of every scientific worker:

> I am a part of all that I have met;
> Yet all experience is an arch wherethro'
> Gleams that untravell'd world whose margin fades
> Forever and forever when I move.
> How dull it were to pause, to make an end,
> To rust unburnish'd, not to shine in use!
> As tho' to breathe were life! Life piled on life
> Were all too little, and of one to me
> Little remains, but every hour is saved
> From that eternal silence, something more,
> A bringer of new things, and vile it were
> For some three suns to store and hoard myself,
> And this gray spirit yearning in desire
> To follow knowledge, like a sinking star,
> Beyond the utmost bound of human thought.

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EUGENE WOLDEMAR HILGARD, A BIOGRAPHICAL SKETCH

EUGENE WOLDEMAR HILGARD was born January 5, 1833, at Zweibruecken, in Rhenish Bavaria, the son of Theodore Erasmus and Margarethe Hilgard, and was the youngest of a family of four sons and five daughters. His father was a lawyer, holding the position of chief justice of the court of appeals of the province. Judge Hilgard, having been born and educated under the shadow of the French Revolution, and being of pronounced liberal views, stoutly opposed the supersedence of the code Napoleon by the illiberal laws of the old régime. In 1836, when at the fullness of a successful career, he determined to emigrate to America with his family and settled on a farm at Belleville, Illinois. As the public schools of that day were quite primitive, Judge Hilgard personally undertook the preparation of his sons for entrance to the universities. Eugene was in readiness in 1849 and in that year returned to Germany to attend the University of Heidelberg, graduating with honors and a doctor's degree with *summa cum laude* in 1853. This degree was re-issued to him in 1903 as a "golden degree" in recognition of half a century's good work for science. He studied also in Zurich and Freiberg, in Saxony. After graduating in 1853 he visited Spain and met Miss J. Alexandrina Bello, daughter of Colonel Bello, of the Spanish army, whom he married several years later. Returning to America, he began geological exploration work in Mississippi in 1855 and was appointed state mineralogist of that state in 1858. In 1860 he revisited Spain, married